# SST ERROR OF DRIFTING BUOYS: POSSIBLE EDDY EFFECT?

**Alexey Kaplan**

*Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA*

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# Motivation

- Platform-related biases (~0.3C) for drifting buoys are needed to model realistically relatively slow error reduction in regional and temporal averages (Kent and Berry 2008; Kennedy et al. 2012)
- Instrument studies for drifting buoys seem to produce much smaller biases, and there is no clear mechanism that would be responsible for larger biases.
- What could be the explanation?

# Example: P observational platforms, K observations from each

Measurements from these platforms are characterized by biases $b^p,\ p=1,\cdots,P$ and by the random error on top of them, so that $K$ observations from $p$-th platform will have errors as follows:

$$e_k^p = b^p + \varepsilon_k^p, \quad k=1,\cdots,K,$$

where $\varepsilon_k^p$ for all $p$ and $k$ are independent random numbers with zero mean and standard deviation $\sigma$. Since $p$-th platform's bias value $b^p$ does not depend on $k$, it is the same for all errors $e_k^p,\ k=1,\cdots,K$ of this platform's measurements. But biases of different platforms $b^p,\ p=1,\cdots,P$ are independent random numbers from a probability distribution with zero mean (assumed this way for simplicity here) and standard deviation $\beta$. Obviously, the mean error of our $PK$ observations is

$$\bar{e} = \frac{1}{PK}\sum_{p=1}^{P}\sum_{k=1}^{K}(b^p+\varepsilon_k^p) = \frac{1}{P}\sum_{p=1}^{P}b^p + \frac{1}{PK}\sum_{p=1}^{P}\sum_{k=1}^{K}\varepsilon_k^p,$$

and the variance of the mean error (the expectation of its squared value) is

$$\mathrm{E}\bar{e}^2 = \frac{\beta^2}{P} + \frac{\sigma^2}{PK}. \tag{1}$$

# Example:
# P observational platforms, K observations from each

## Conclusions

Recall that $PK$ is the total number of observations averaged by $\bar{e}$. Yet, according to Equation (1), when $PK$ becomes so large that

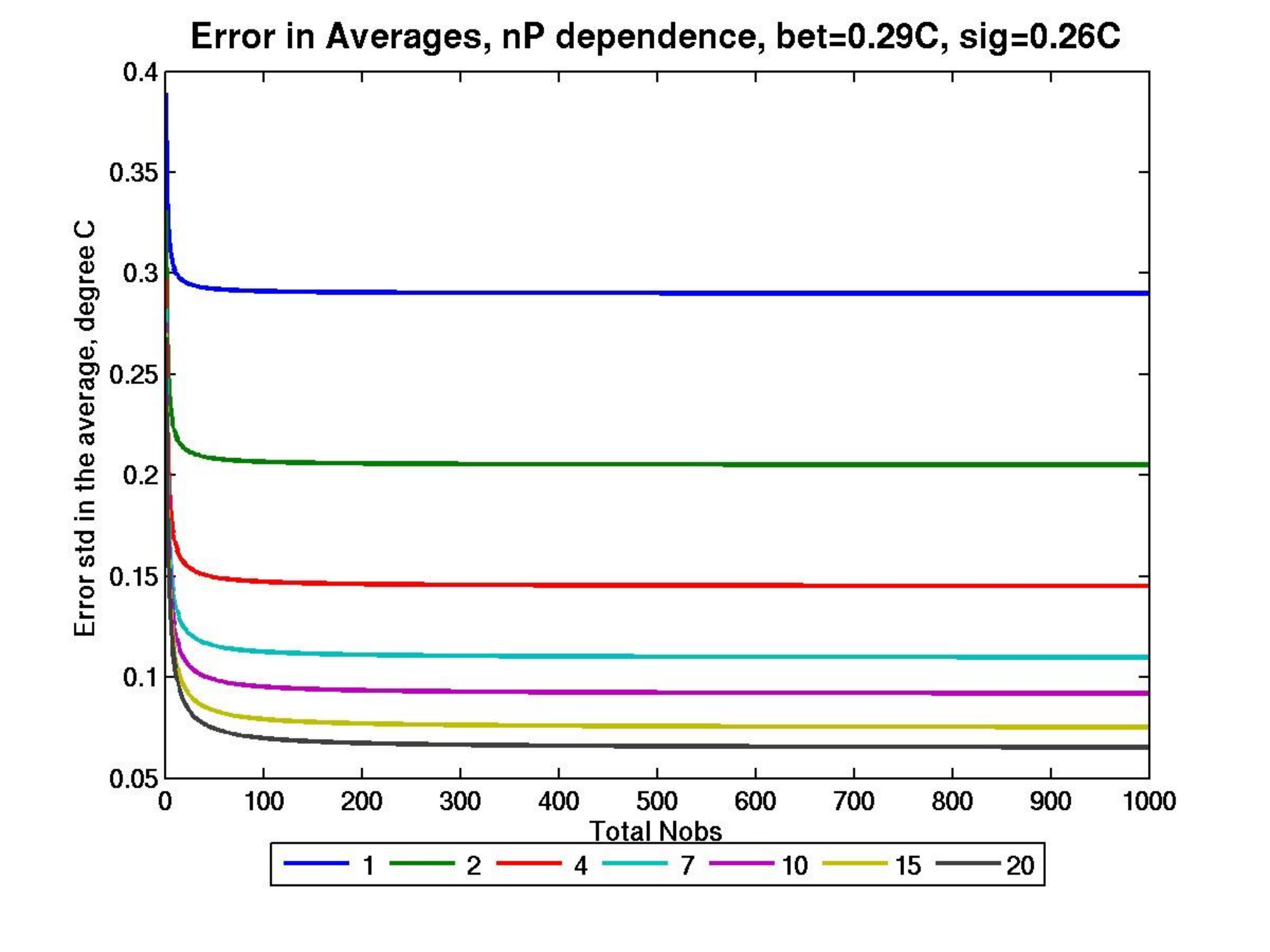
$$\frac{\sigma^2}{PK} \ll \frac{\beta^2}{P},$$

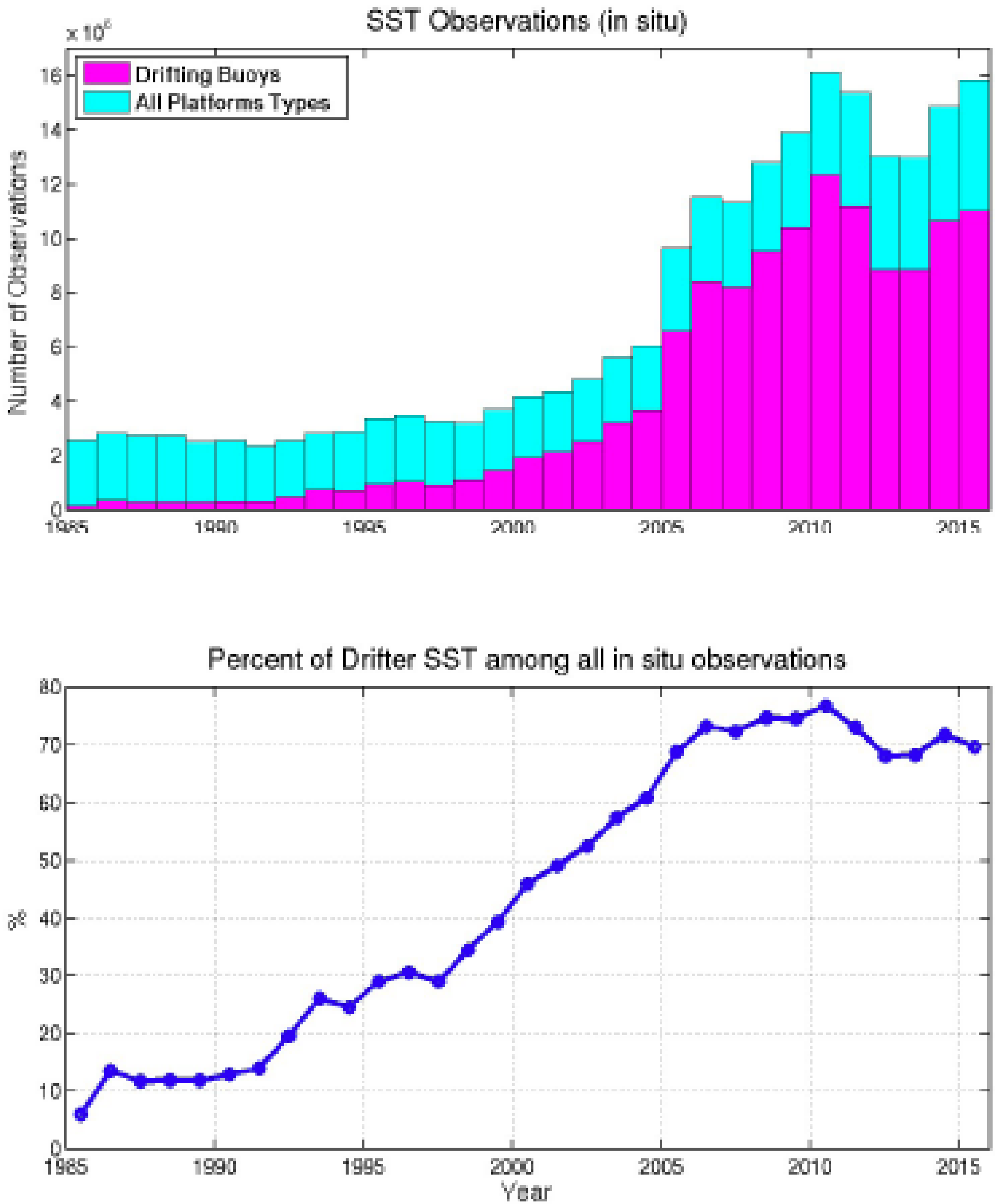
mean error variance $\mathrm{E}\bar{e}^2$ decreases to the value, which is essentially independent of the total number of observations:

$$\mathrm{E}\bar{e}^2 \approx \frac{\beta^2}{P}.$$

Instead, it requires an increase in the number of platforms $P$ in order to achieve further reduction.

# Illustration: Drifting Buoys, Kennedy et al (2012) total nobs = 1-1000, nP = 1-20






**Drifting buoys' dominance in the 21st century among all in situ SST observations**

**Top panel: annual totals of SST measurements from drifters (magenta), annual totals of all in situ SST observations (cyan).**

**Bottom panel: annual percentage of SST measurements from drifting buoys among all in situ observations of SST.**

**[based on ICOADS]**

# Hypothesized:

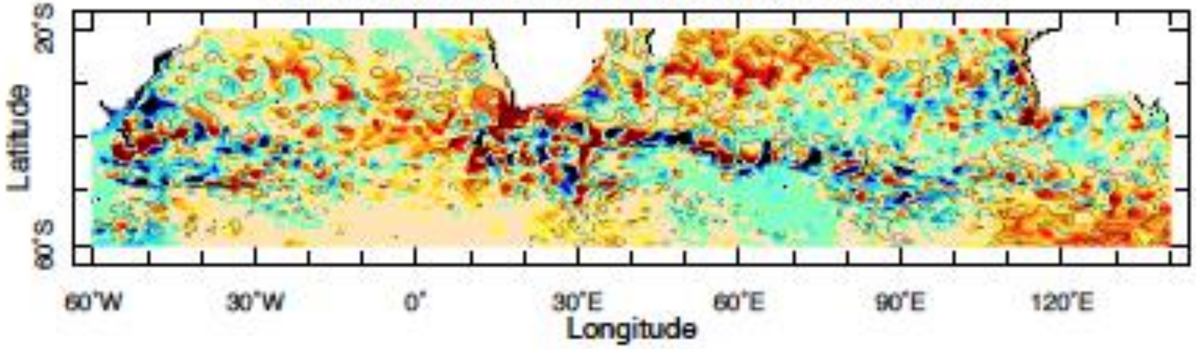
1. A significant number of drifting buoys is captured by ocean eddies and travel within them for some part of their trajectories;

2. There are systematic differences between the SST of eddy cores and of the surrounding water;

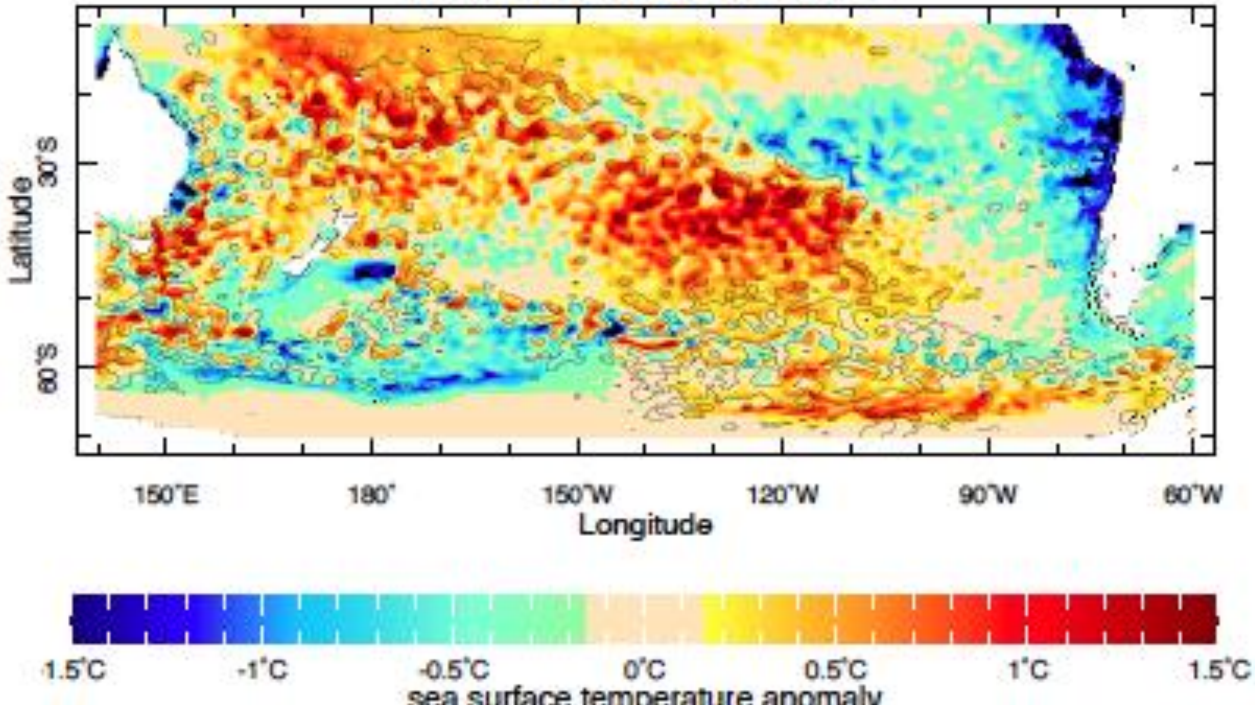
3. The latter SST differences are partly responsible for the apparent biases of the SST measured by drifting buoys, with regards to the larger area averages.

# Anomalies of SST (colors) and SSH (contours of ±8cm) July 2007

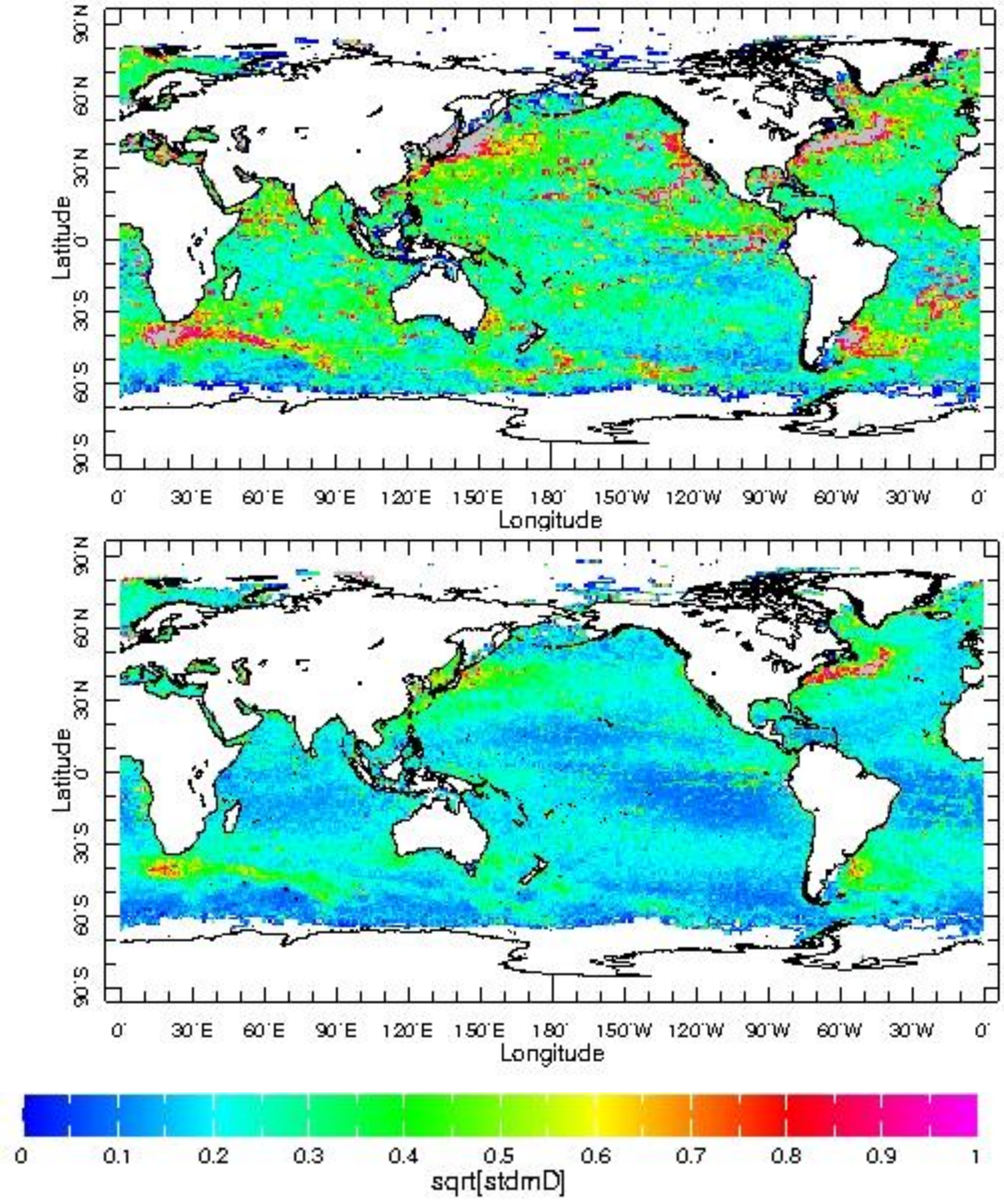
## South Atlantic and Indian Ocean sectors




## South Pacific Ocean sector



# Individual Drifters – OSTIA Comparison




**1x1deg daily gridbox std diff**

**0.05x0.05 deg daily std diff**

## CONCLUSIONS - GENERAL

**While the number of in situ sea surface temperature (SST) observations of the global ocean has been increasing rapidly, the accuracy of regional and even global estimates of mean SST is improving more slowly than what the increase in the number of independent observations would suggest. The current explanation invokes the systematic biases of individual platforms (ships or buoys). This effect is particularly important for drifting buoys, which usually stay in the ocean for 1-2 years and report measurements often, thus providing the majority of all in situ SST observations of the last decade. A possibility is investigate that these errors are, at least partly, due to the effect of ocean eddies.**

# CONCLUSIONS - DETAIL

It is suggested that a significant number of drifting buoys is captured by ocean eddies and travel within them for some part of their trajectories; there are systematic differences between the SST of eddy cores and of the surrounding water, which are partly responsible for the apparent biases of the SST measured by drifting buoys, with regards to the larger area averages. Comparison of SST measurements from drifting buoys with the CCI version of the OSTIA reanalysis (i.e., SST product on ~6km grid, no in situ data) found significant correlation of buoys' and OSTIA's temperature deviations from the 1oX1o box means. Large number of ocean eddies are found to be co-located with small-scale SST anomalies. However, in many ocean areas the trajectories of drifting buoys seem not to be consistent with eddy trajectories.